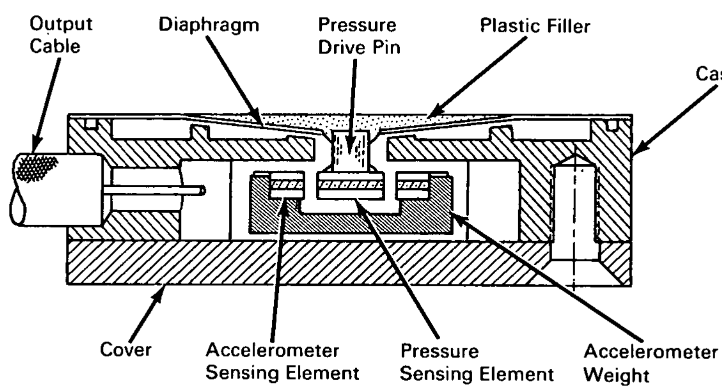
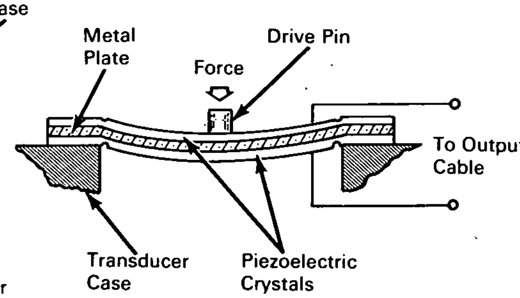
NASA TECH BRIEF

Acceleration-Compensated Pressure Transducer Has Fast Response



TRANSDUCER ASSEMBLY



SENSING ELEMENT CONSTRUCTION AND MOUNTING DETAIL

The problem:

To design a flush-diaphragm transducer that will accurately measure small dynamic pressures when it is subjected to high accelerations and severe temperature environments. A flush-diaphragm design offers a potentially faster response to dynamic variations of low pressures than a conventional nonflush transducer which uses a short length of pressure tubing.

The transducer was required to meet the following specifications for measuring pressures on flat model surfaces in hypersonic shock tunnel tests:

Pressure range: 0.25 to 0.005 psid
Allowable pressure: 30 psi (without damage)
Natural frequency: 5,000 cps or higher
Acceleration response: Zero output
Temperature effects: Thermal insulation on exposed surface of diaphram to protect transducer from both conductive and radiative heat.
Size: Approximately 0.5-inch diameter and 0.25-inch thick

The solution:

A flush-diaphragm transducer employing piezoelectric crystals for measuring pressure and balancing out acceleration forces.

How it's done:

The pressure diaphragm is flat at the periphery and conical towards the center, where it is filled with an epoxy resin to form a flat surface. A thin layer of relatively soft material (e.g., natural rubber) is bonded to this surface to provide a heat barrier. Overload stops are provided behind the diaphragm to reduce maximum stress at the drive pin connection. The accelerometer crystal is connected to a weight rather than to a second diaphragm as in the conventional nonflush transducer. This weight is accessible for adjustment by removing the cover from the transducer. The provision for adjustment of the accelerometer weight allows compensation for the sensitivity difference between the pressure and accelerometer crystals. When the accelerometer and pressure assemblies are identical in mass and sensitivity, no output

(continued overleaf)

will result from acceleration forces acting on the transducer.

Each of the three sensing elements is constructed by cementing plates of oppositely polarized piezoelectric material (lead zirconate titanate) to the top and bottom surfaces of a thin metallic plate. The ends of the three elements are cemented to the transducer case. Each element thus acts as a simply supported beam loaded at its center by a concentrated force. The resulting charge displacement is in the same direction, since both the polarization and applied stress are reversed in direction between the top and bottom halves of the beam.

A single output cable is attached to the transducer because internal wiring is used to connect the electrical outputs of the pressure and accelerometer crystals in parallel opposition, rather than in series opposition as in the conventional design. Parallel wiring has the advantage that electrical leakage across the sensing elements is easily detectable at the transducer output. For the crystal capacitances used in this design the parallel wiring results in higher signals than series wiring when the length of the output cable exceeds 20 feet.

Notes:

1. Tests of the transducer mounted on flat model surfaces in hypersonic shock tunnel tests indicate that it affords adequate thermal protection for heating rates of 4.7 Btu per sq ft per sec at pressures of 0.0037 psia. Acceleration sensitivity was found to be low enough to allow the transducer to measure pressure on the windward side of models.
2. The rise time of this transducer was found to be about one-fifth that of a conventional nonflush transducer under the same test conditions.
3. The piezoelectric elements must be matched for high sensitivity to applied stress.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia 23365
   Reference: B66-10353

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Cornell Aeronautical Laboratory, Inc.
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